Chapter 29
Using Multi-Agent Systems to Support e-Health Services

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ABSTRACT

Multi-agent systems have been importantly contributing to the development of the theory and the practice of complex distributed systems and, in particular, they have shown the potential to meet critical needs in high-speed, mission-critical, content-rich, and distributed information applications where mutual interdependencies, dynamic environments, uncertainty, and sophisticated control play a role. Multi-agent systems can be considered a suitable technology for the realization of applications for providing e-health services where the use of loosely coupled and heterogeneous components, the dynamic and distributed management of data, and the remote collaboration among users are often the most relevant requirements.

1. INTRODUCTION

Multi-agent systems are one of the most interesting areas in software research and they have been importantly contributing to the development of the theory and the practice of complex distributed systems (see, e.g., Jennings et al., 1995; Muller, 1998; Bordini et al., 2005) and, in particular, they have shown the potential to meet critical needs in high-speed, mission-critical, content-rich and distributed information systems where mutual interdependencies, dynamic environments, uncertainty, and sophisticated control play a role (Gasser, 2001). Application for e-health services can take outstanding advantage of the intrinsic characteristics of multi-agent systems because of notable features that most e-health services and applications share: *(1)* they are composed of

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loosely coupled (complex) systems; *(2)* they are realized in terms of heterogeneous components and legacy systems; *(3)* they dynamically manage distributed data and resources; and *(4)* they are often accessed by remote users in (synchronous) collaboration (Moreno & Nealon, 2003; Annicchiarico et al., 2008).

The goal of this chapter is to describe the main reasons why multi-agent systems are considered one of the most interesting technologies for the development of applications for e-health services. It provides some guidelines intended to help identifying the kinds of applications that can truly take advantage of the features of multi-agent systems, and it presents some of the most important international projects that used multi-agent systems for the provision of innovative e-health services.

2. BACKGROUND

While a number of definitions have been proposed for identifying a "software agent" and a "multi-agent system" (see, e.g., Russell & Norvig, 2003; Wooldridge & Jennings, 1995; Genesereth & Ketchpel, 1994), there is not a single one which researchers generally agree on. Nevertheless, there is a common understanding that an agent is essentially an autonomous software entity that should at least be designed to operate continuously in dynamic and uncertain environments, reacting to events while showing an intelligent behaviour to pursue its own objectives. An agent usually provides interoperable interfaces for interacting with other agents, either concurrently or cooperatively, exchanging messages formulated according to some syntax, semantics, and pragmatics. Since an agent behaves proactively, it requires some degree of trust by its user, and it can receive delegations from either human users or other agents in the form of required actions or desired goals, matched with permissions to access necessary resources. Additionally, some agents may also be able to perform complex reasoning at run-time and also learn and change their behaviour over time, to improve their performances. Mobile agents are even able to move for one computational node to another, to follow their own users or to exploit some local resource more efficiently. Agent-based systems are often realized by loosely coupling various agents, i.e. autonomous software entities, thus modelling a proper multi-agent system, characterised by a higher level of modularity and a richer descriptive model, if compared with a solitary agent working within its environment—either with the presence of users or not.

As agents are often described in terms of the generic properties that they should exhibit, instead of a precise programming interface or algorithm, they are better thought as abstractions capable of capturing the essence of many software systems at different levels of detail, rather than a single technology supporting the realization of distributed intelligent systems. In this sense, diverse systems in the fields of Artificial Intelligence, Databases, Operating Systems, and Computer Networks can be coherently considered as first-class multi-agent systems. In particular, agents and multi-agent systems are often considered the highest system level (Newel, 1982; Jennings, 2000) that we can access today and they are meant to provide a truly novel level of abstraction in the analysis, design and implementation of complex software systems (Bergenti & Huhns, 2004). Since the agent-based nature of a system comes from the characteristics of its components and of the interactions between them, multi-agent systems are often developed using technologies that have been recently provided for the main purpose of realizing highly interoperable software systems, e.g., Web services, and that have no built-in notion of agent.